

# *EDSN - Edison Demonstration for SmallSat Networks*

## *The EDSN Intersatellite Communications Architecture*

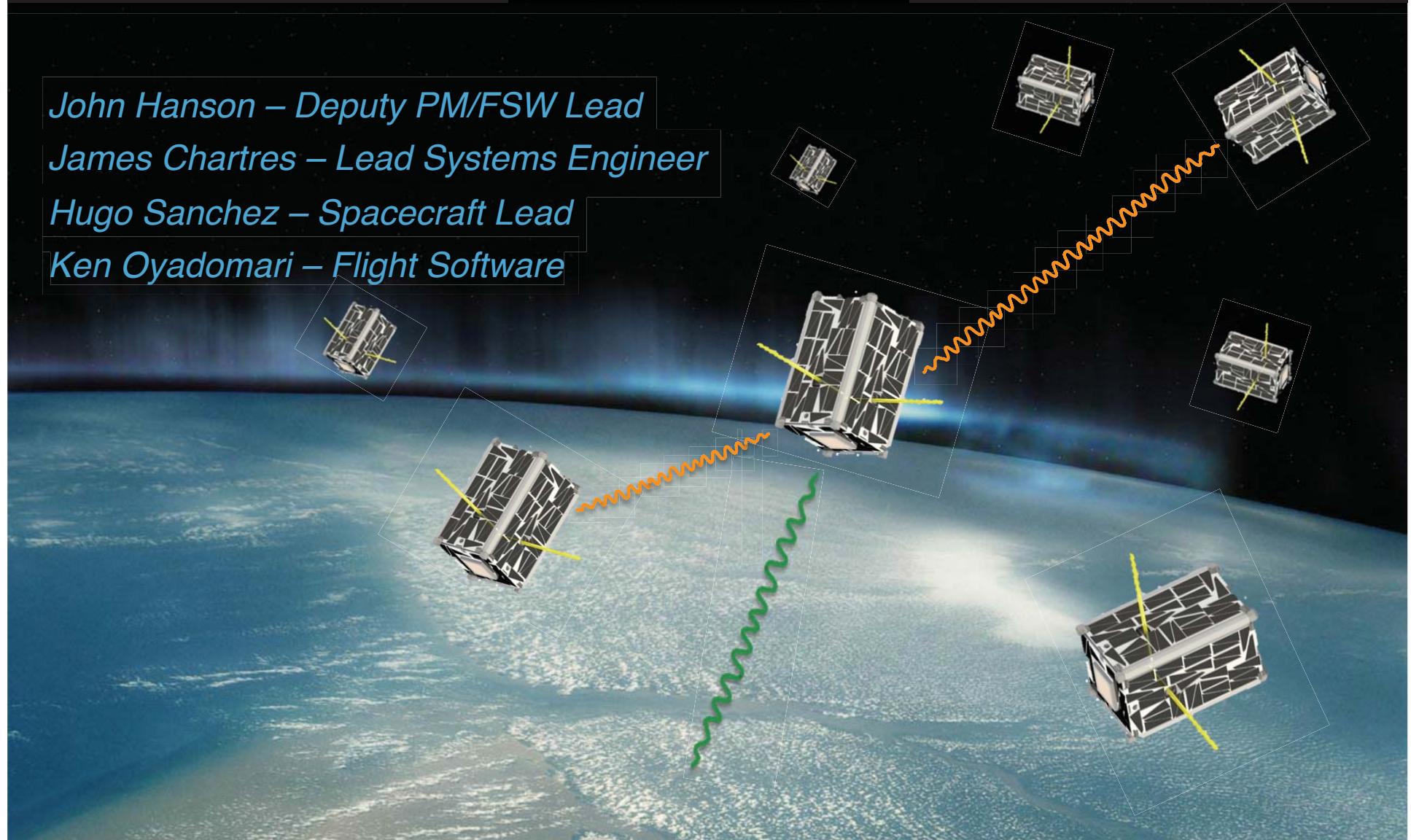
*Tuesday, 5<sup>th</sup> August, 2014*

*John Hanson – Deputy PM/FSW Lead*

*James Chartres – Lead Systems Engineer*

*Hugo Sanchez – Spacecraft Lead*

*Ken Oyadomari – Flight Software*





# Science with Swarms

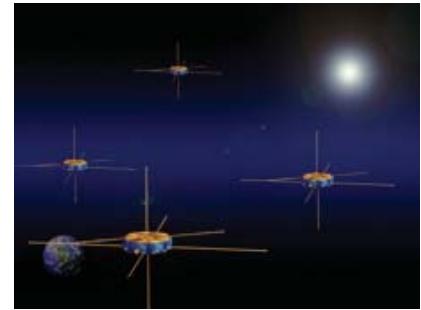
- Probing Earth-Sun interactions with gradient measurements of magnetosphere properties
- Synthetic aperture radar
- Multi-point tomographic measurements
- Geopotential measurements
- Large sparse array telescopes
- Coronograph based missions
- Explore properties of other planets, comets and near-Earth objects



[http://www.darpa.mil/.../System\\_F6.aspx](http://www.darpa.mil/.../System_F6.aspx)



[http://www.esa.int/.../About\\_Proba-3](http://www.esa.int/.../About_Proba-3)



<http://mms.gsfc.nasa.gov/>



<http://gracetellus.jpl.nasa.gov/>



# Cubesat Challenges

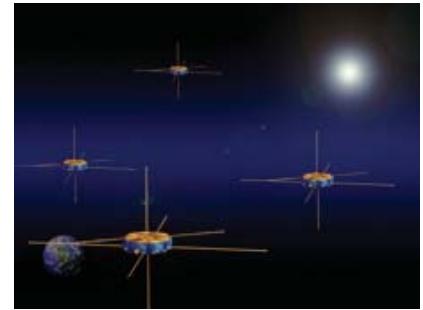
- Low electric power availability
- Limited ADCS hardware
- Ground support systems
- Maximizing available mass and power for payloads



[http://www.darpa.mil/.../System\\_F6.aspx](http://www.darpa.mil/.../System_F6.aspx)



[http://www.esa.int/.../About\\_Proba-3](http://www.esa.int/.../About_Proba-3)



<http://mms.gsfc.nasa.gov/>



<http://gracetellus.jpl.nasa.gov/>



# EDSN Mission Objectives

## Mission Goal

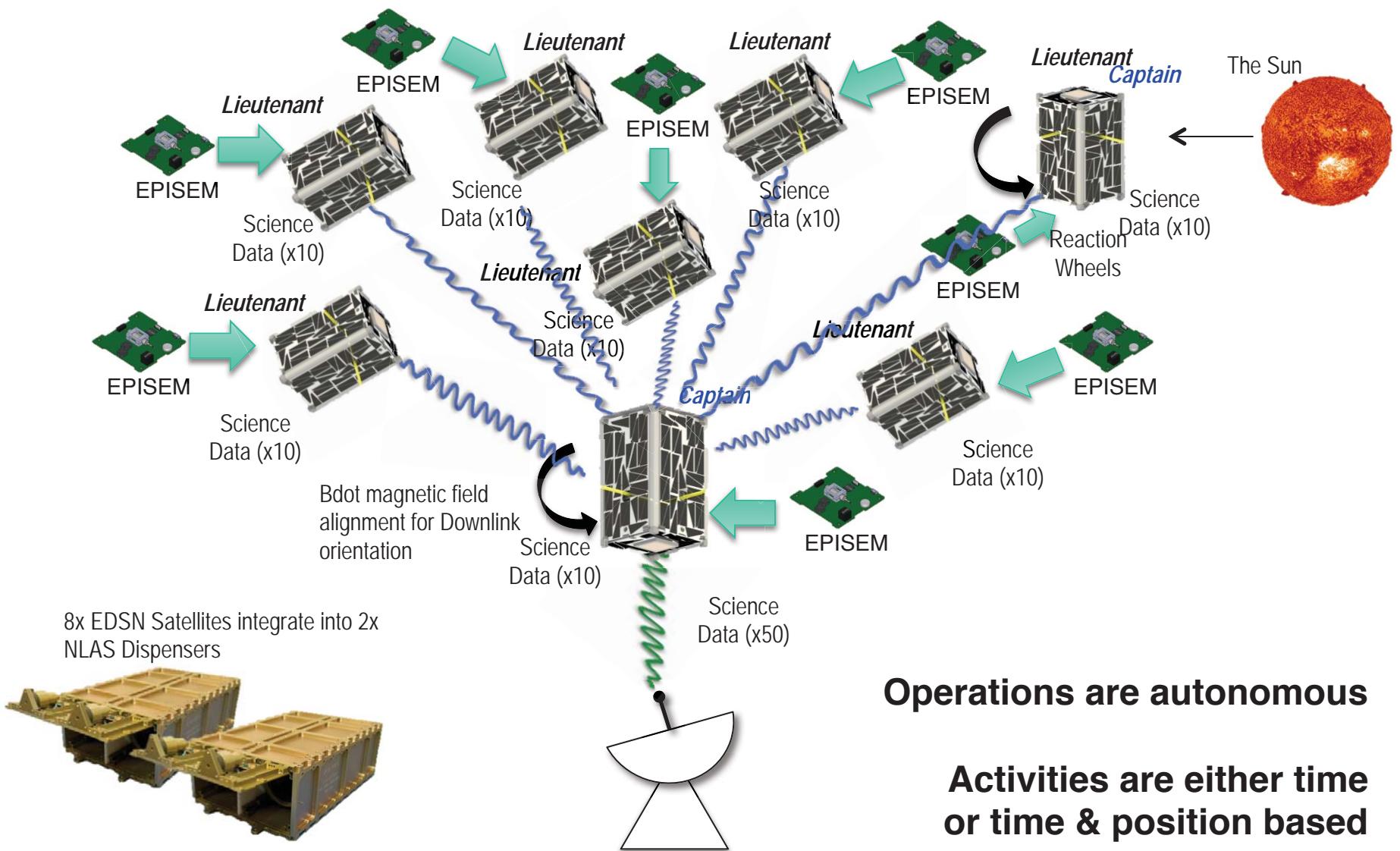
**Demonstrate that a swarm of satellites is capable of collecting multi-point science data and transferring the data to the ground**

## Mission Objectives

1. **Flight demonstrate one-way space-to-space data transfer whereby at least 2 satellites transfer data to a third satellite, which then transfers the data to the ground**
2. **Flight demonstrate a system to collect multi-point science measurements, transfer science measurements to another satellite and transfer to the ground**
3. **Flight demonstrate a reaction wheel based pointing system.**
4. **Assess the viability of satellites built with Commercial Off The Shelf (COTS) components to operate for 60 days**



## Mission Overview

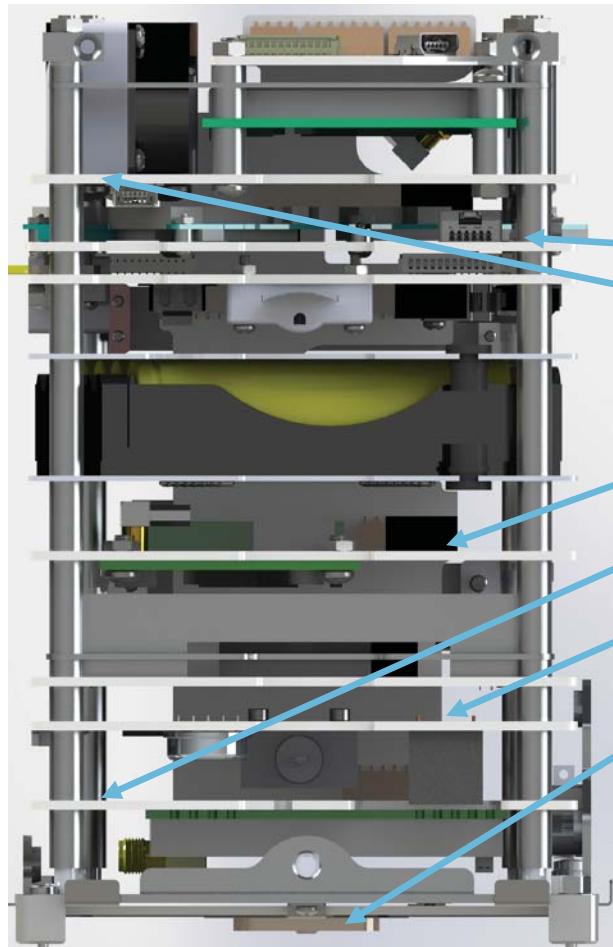




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# EDSN Spacecraft Characteristics

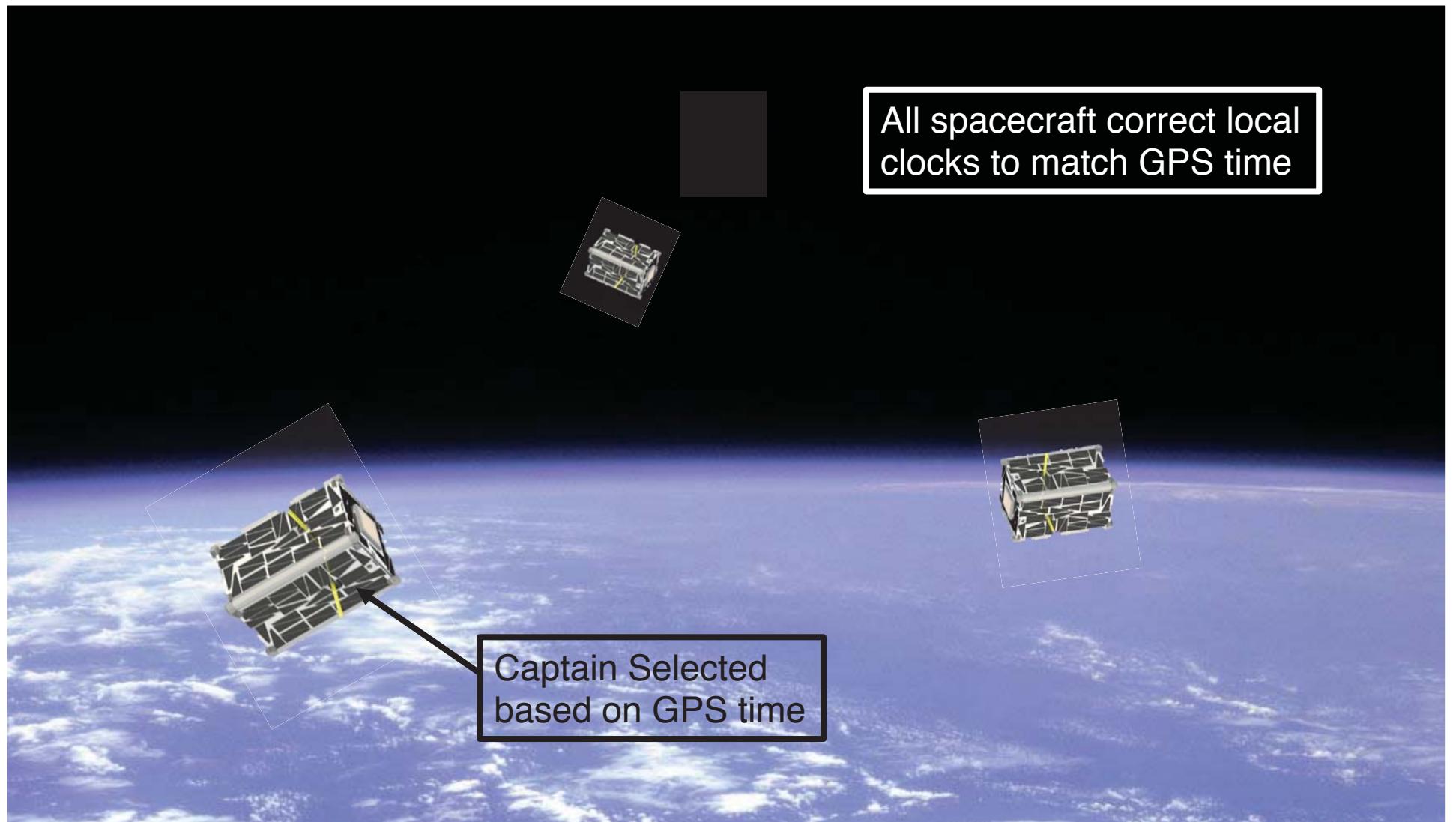


- 1.5U Cubesat
- Primary processor – Nexus S Phone
- MicroHard MHX2420 S-band (downlink)
- Stensat UHF Beacon
- AstroDev Li-1 UHF transceiver (crosslink)
- EPISEM payload
- Novatel OEMV-1 GPS Receiver
- Li-Ion Batteries (2800 mAh)
- 1 W orbit average power



## 1. Acquire GPS Solution

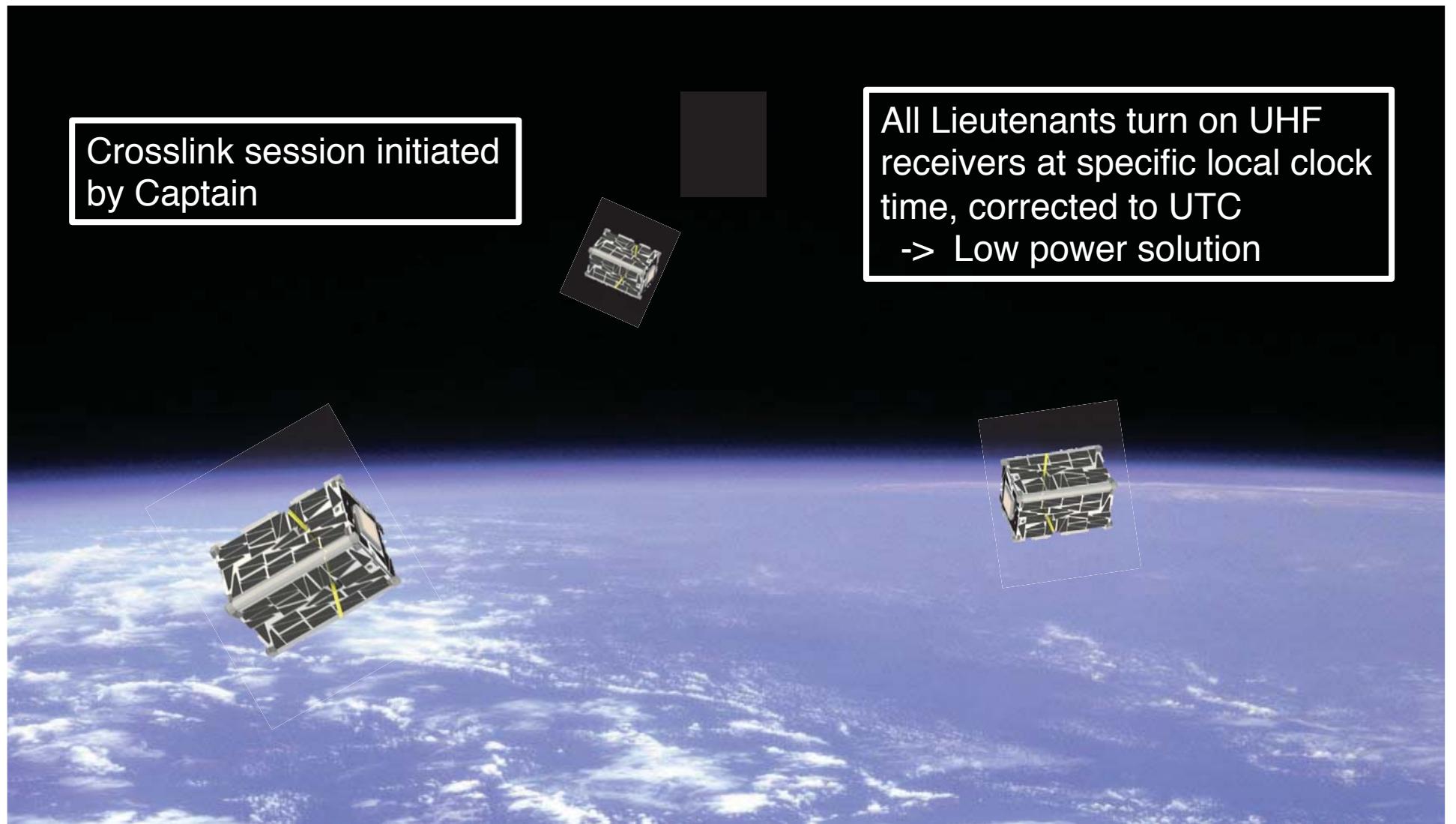
## Comms Architecture





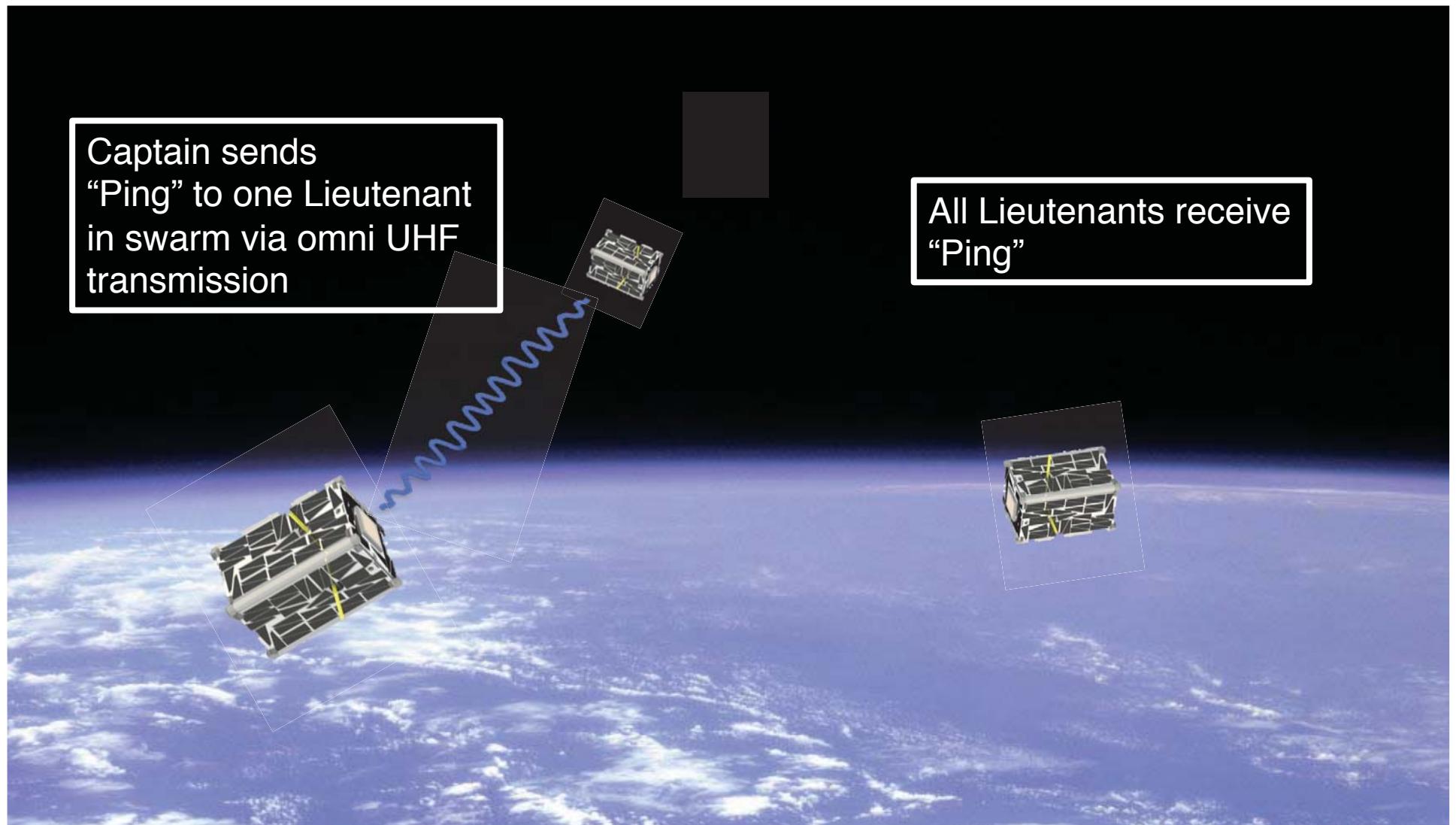
## 2. Initiate Crosslink Session

## Comms Architecture



## 2a. Initiate Crosslink Transaction

## Comms Architecture



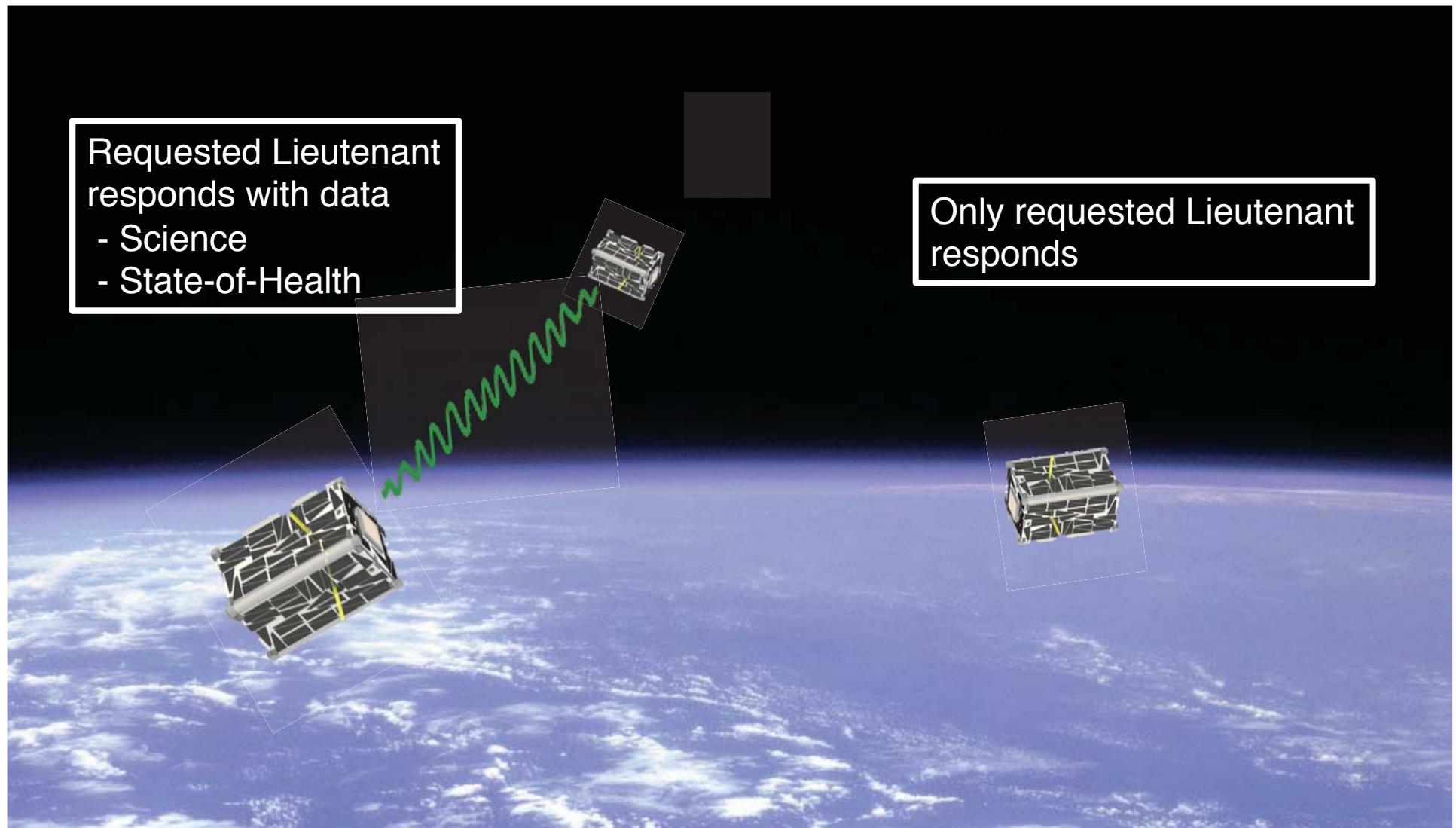


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## 2b. Collect Crosslink Data

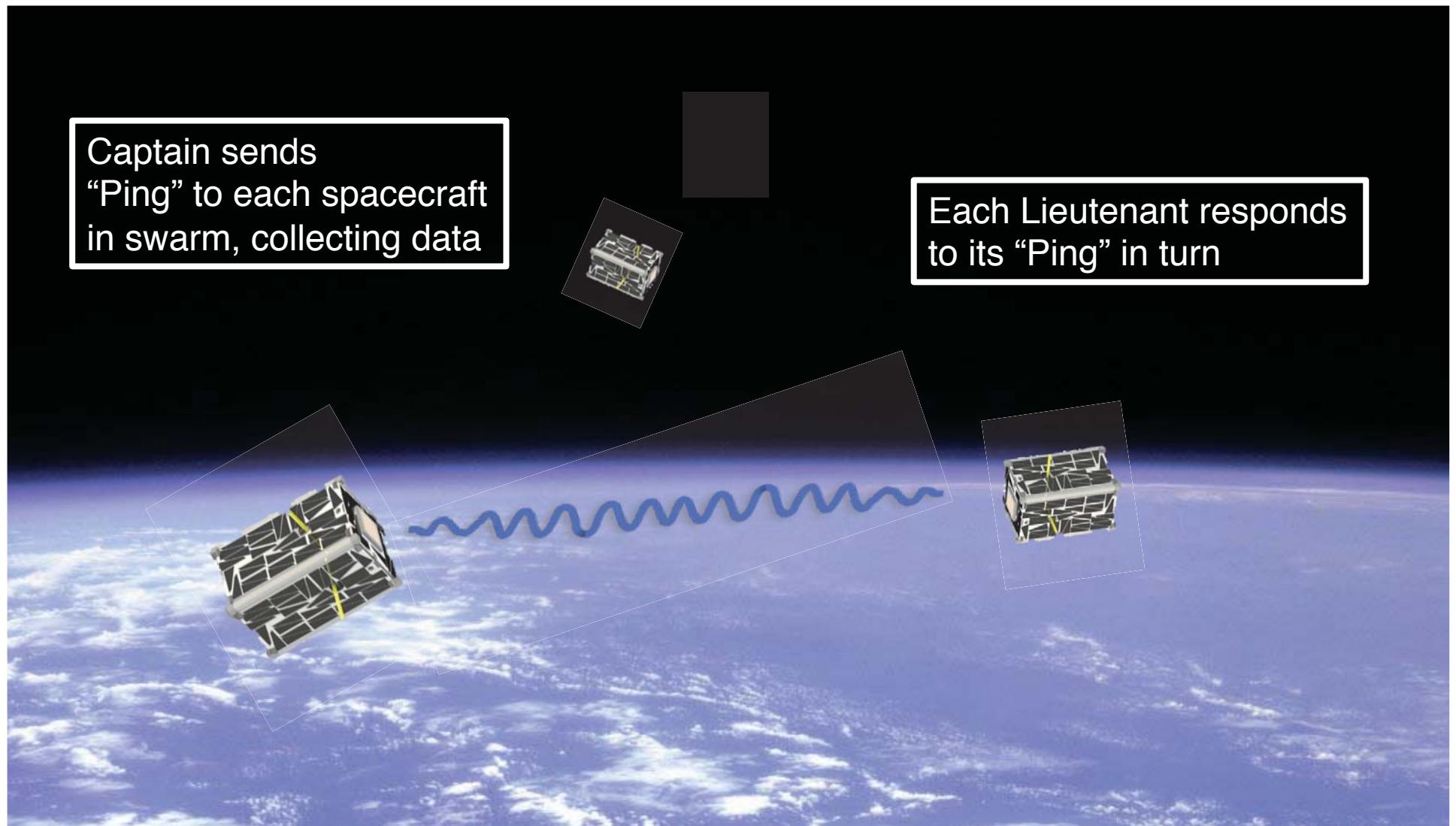
## Comms Architecture





## 2c. Collect Data from Swarm

## Comms Architecture



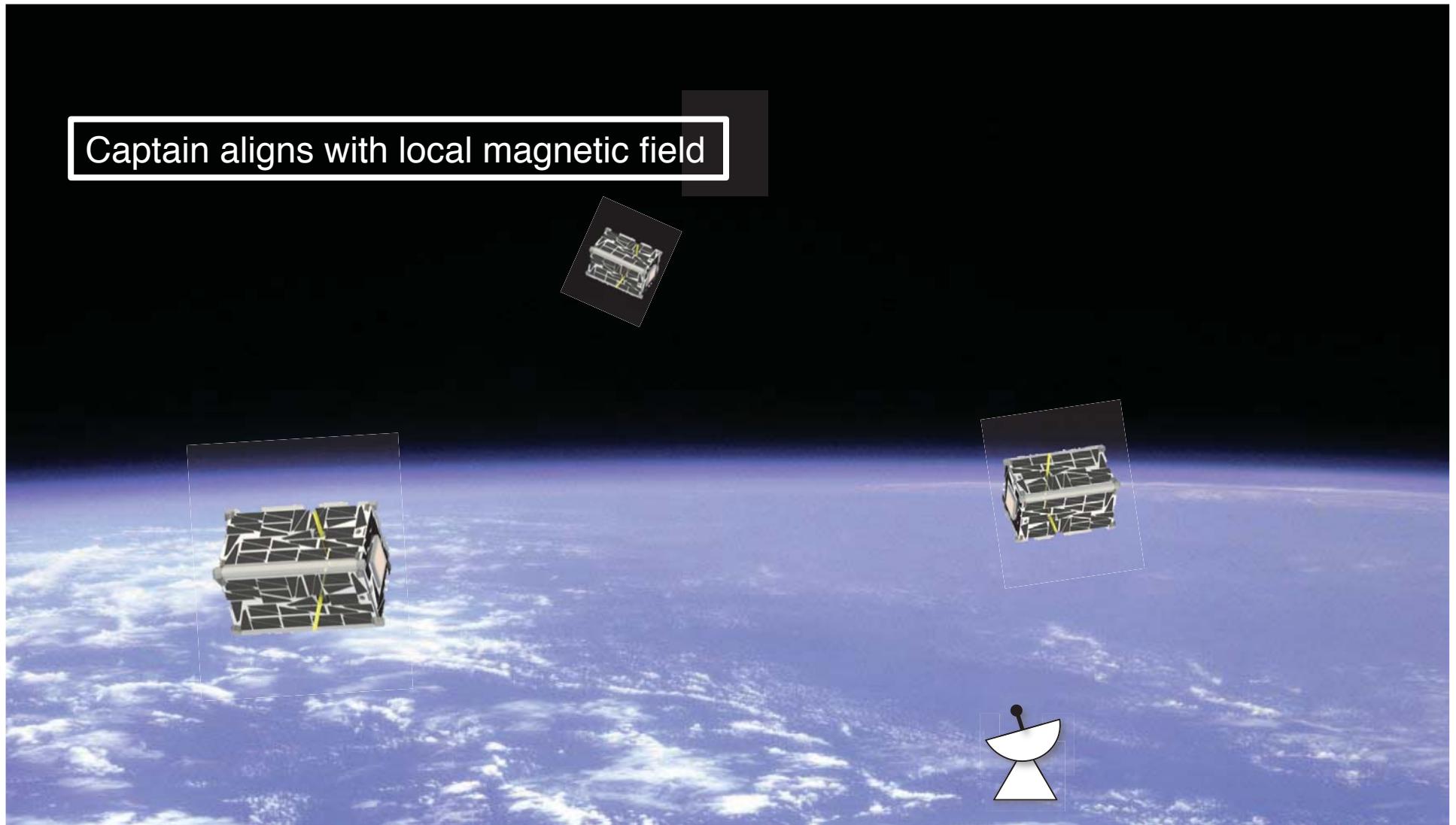


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### 3. Initiate Downlink Activity

## Comms Architecture





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## 4. Send Data to Ground

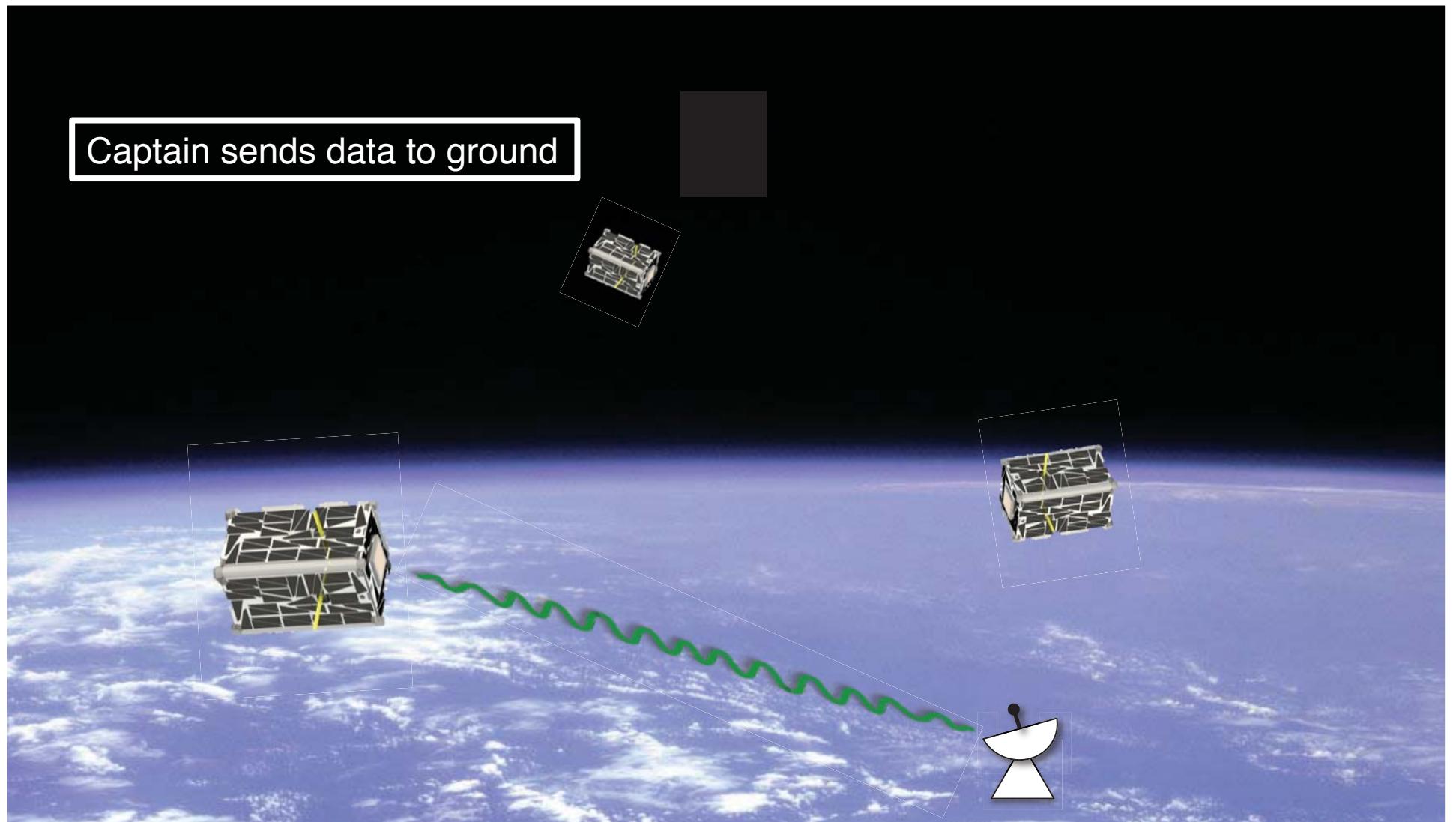
# Comms Architecture





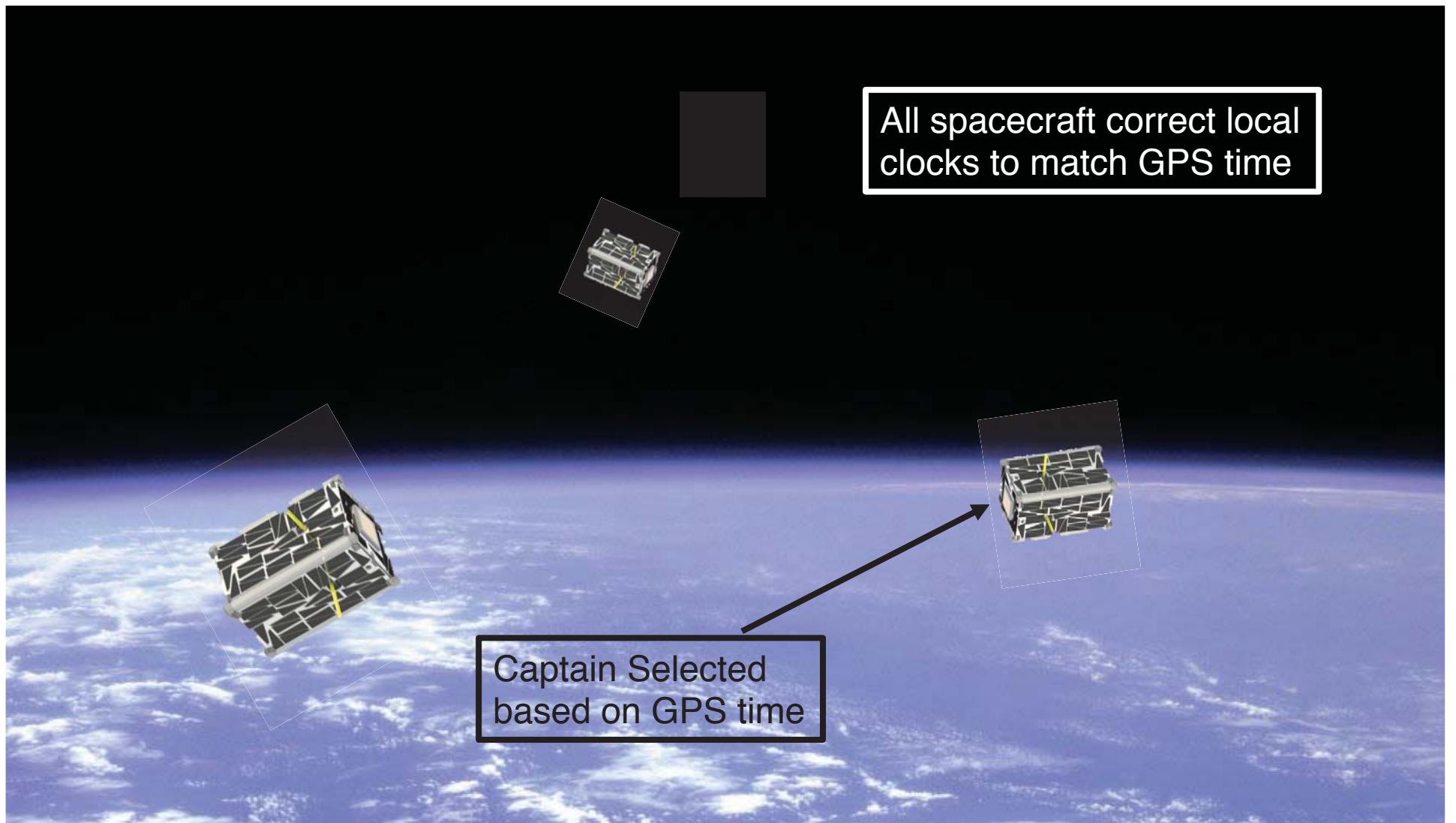
## 4. Send Data to Ground

## Comms Architecture



## 1. Acquire GPS Solution ...

## Comms Architecture



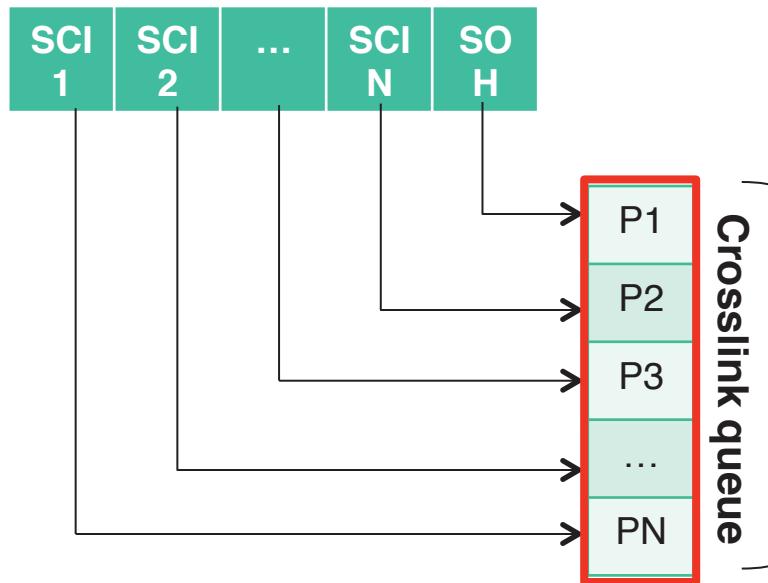


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# Crosslink

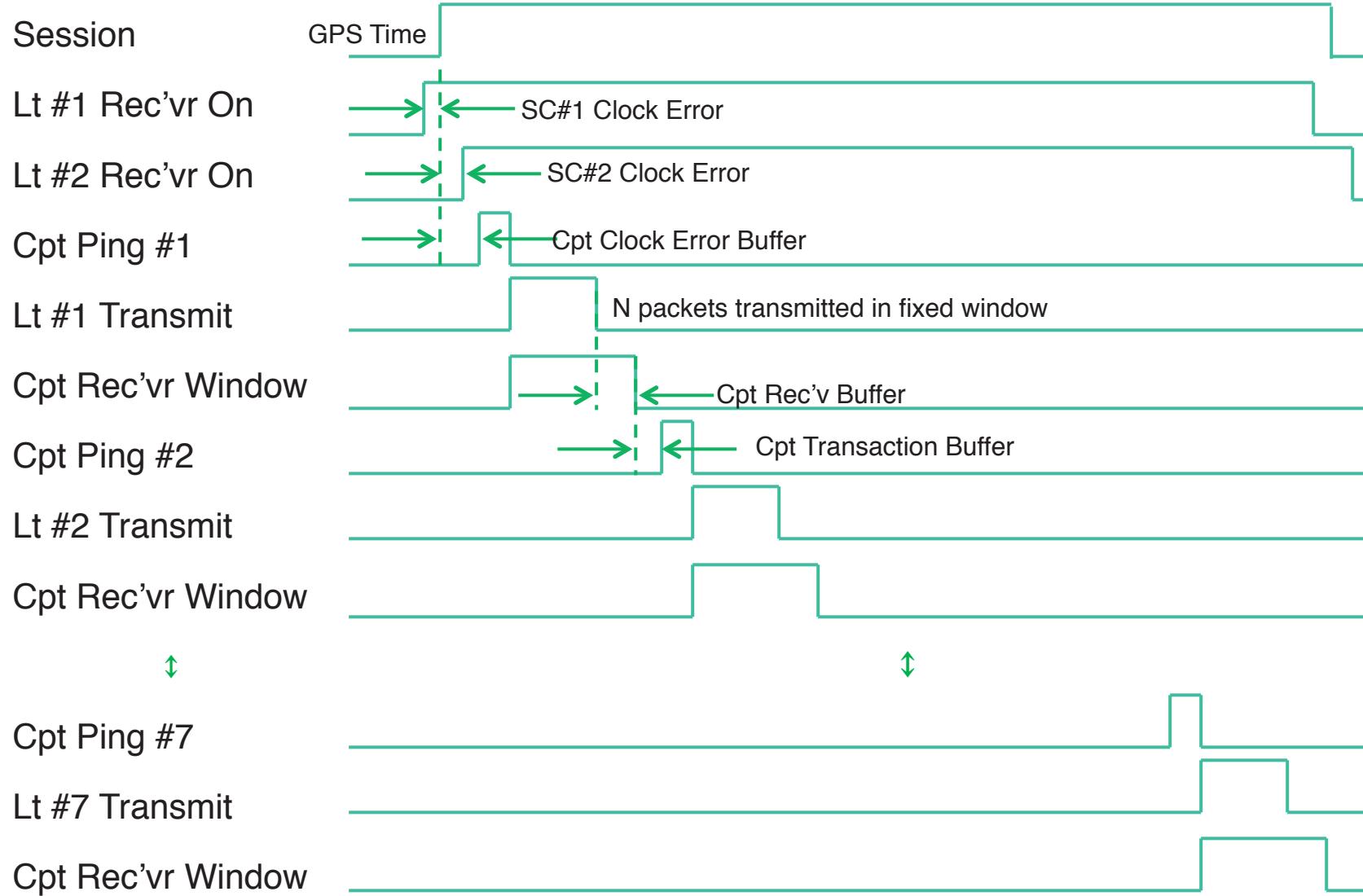
## Crosslinked Packets from LT



Packets in the downlink stack **from previous sessions** or major cycles are pushed down in the stack

## downlink stacks

| CPT | LT1  | LT2 | LT3 | ... | LT7 |
|-----|------|-----|-----|-----|-----|
| PtP | P1   | P1  | P1  | ... | P1  |
| SOH | P2   | P2  | P2  | ... | P2  |
| SC1 | P3   | P3  | P3  | ... | P3  |
| SC2 | P4   | P4  | P4  | ... | ... |
| SC3 | P5   | P5  | ... | ... | ... |
| ... | P1-0 | ... | ... | ... | ... |
|     | P2-0 |     |     |     |     |
|     | P3-0 |     |     |     |     |
|     | P4-0 |     |     |     |     |
|     | P5-0 |     |     |     |     |
|     | ...  |     |     |     |     |

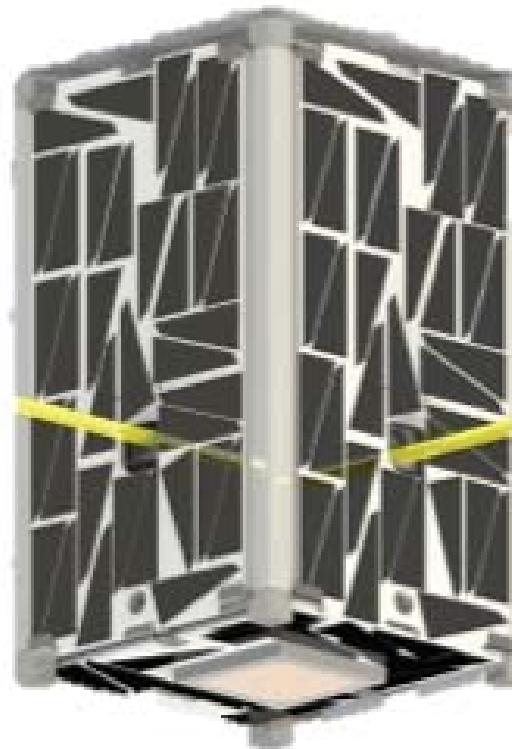






## EDSN Demonstrates ...

- Time synchronized measurements on spatially distributed platforms
- One-way operation of the swarm (data collection) through a single spacecraft that is in periodic contact with the ground
- Autonomous operation of the swarm (i.e. without intervention from ground control)
- Redundancy in swarm operations through the simple, pre-scripted periodic hopping of the Captain





# Future Enhancements

- Routing of ground commands through network
- Autonomous configuration and control of the network by the swarm
- Time synchronized measurements by command from the Captain
- Improved synchronization of time across the swarm
- Improved formation knowledge through DGPS
- Mapping of network topology
- Routing of packets through the network by multiple hops
- Multiple Captains
- Passing of large data files between spacecraft (e.g. image files)
- Prioritization of data messages by the Captain or Lieutenant for downlink
- Addition of ACK/NACK protocol
- Multiple ground stations to increase data throughput
- Addition of standard network layer to the system to take advantage of COTS software and protocols
- Interlinking of multiple Captains to create a “cluster of clusters”.

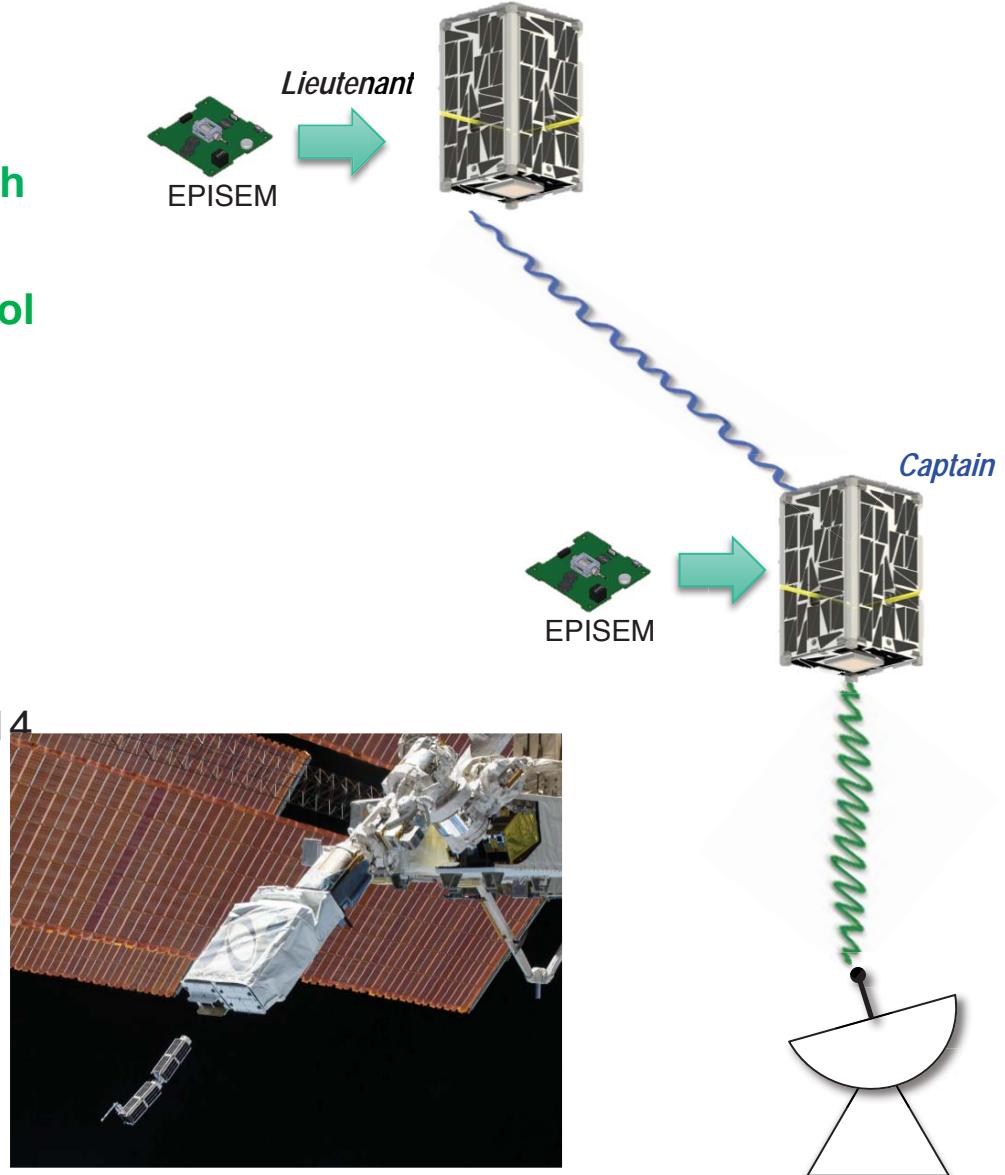


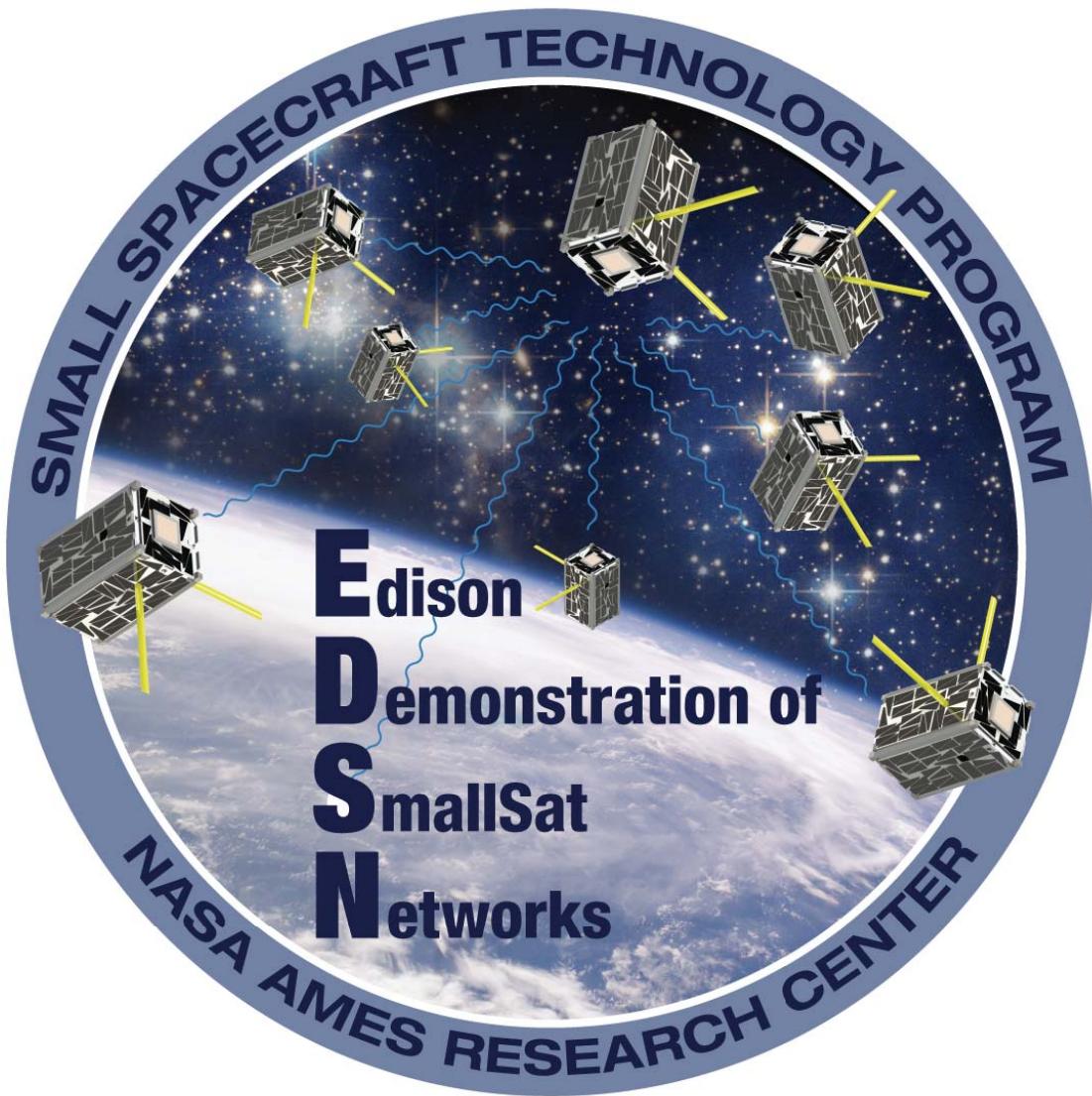
# Future Enhancements

- **Routing of ground commands through network**
- **Autonomous configuration and control of the network by the swarm**

## Nodes

- Demonstration of swarm control technologies
- Delivery to Nanoracks in September, 2014
- Downlaunch from ISS in Q1, 2015





*Questions?*

**Questions?**

